

- V. "Limestone as an Index of Geological Time." By T. MELLARD READE, C.E., F.G.S., F.R.I.B.A. Communicated by A. C. RAMSAY, D.C.L., F.R.S., Director-General of the Geological Survey of the United Kingdom. Received December 24, 1878.

(Abstract.)

The geological history of the globe is written only in its sedimentary strata, but if we trace its history backwards, unless we assume absolute uniformity, we arrive at a time when the first sediments resulted from the degradation of the original crust of the globe.

There is no known rock to which a geologist could point and say "that is the material from which all sedimentary rocks have been derived," but analogy leads us to suppose that if the earth had an igneous origin, the original materials upon which the elements first began to work were of the nature of granite or basalt.

From a variety of considerations drawn from borings, mines, faults, natural gorges and proved thicknesses of the strata of certain mountain chains, the author arrives at the conclusion that the sedimentary crust of the earth is at least of an average actual thickness of one mile, and infers from the proportionate amount of carbonates and sulphates of lime to materials in suspension in various river waters flowing from a variety of formations, that one-tenth of the thickness of this crust is calcareous.

Limestone rocks have been, geology tells us, in process of formation from the earliest known ages, but the extensive series of analyses of water made by Dr. Frankland for the Rivers Pollution Commission, shows that the later strata in Great Britain are much more calcareous than the earlier. The same holds true of the continent of Europe, and the balance of evidence seems in favour of the supposition that there has been on the whole a gradual progressive increase or evolution of lime. The "Challenger" soundings show that carbonate of lime in the form of tests of organisms is a general deposit characterising the greater part of the ocean bottoms, while the materials in suspension are, excepting in the case of transport by ice, deposited within a distance of 200 miles of land.

This wider distribution in *space* of lime, the author thinks, must also profoundly influence its distribution in *time*, and he shows this by example and illustration. It can also be proved to demonstration that the greater part of the ocean bottom must at one time or another

have been land, else the rocks of the continents would have become gradually less, instead of more, calcareous.

Thus the arguments drawn from the geographical distribution of animals are reinforced by physical considerations.

The author goes on to show that the area of granitic and volcanic rocks in Europe and the part of Asia between the Caspian and the Black Sea, as shown in Murchison's map of Europe, is two-twenty-fifths ($\frac{2}{25}$) of the whole; much of this is probably remelted sediments and some of the granites the product of metamorphism.

From considerations stated at length it is estimated that the area of exposures of igneous to sedimentary rocks would be for all geological time liberally averaged at one-tenth ($\frac{1}{10}$) of the whole.

These igneous rocks are either the original materials of the globe protruded upwards, or they are melted sediments or a mixture of the two.

The only igneous rocks we know of are of the nature of granites and traps. If these rocks do not constitute the substratum of the earth, and all known rocks, igneous as well as sedimentary, are derivative, either geological time is infinite, or the rock from which they are derived is, so far as we know, annihilated geologically speaking, and we have no records of it left.

If we assume the latter as true, the past is immeasurable, but in order to arrive at a minimum age of the earth, the author starts from the hypothesis that the fundamental rocks were granitic and trappean.

From eighteen analyses by Dr. Frankland, it is shown that the water flowing from granitic and igneous rock districts in Great Britain contains on an average 3.73 parts per 100,000 of sulphates and carbonates of lime.

The amount of water that runs off the ground is given for several of the great continental river basins in Europe, Asia, Africa, and America. The annual depth of rain running off the granitic and igneous rock areas, taking into consideration the greater height at which they usually lie and the possibility of greater rainfall in earlier ages, is averaged at 28 inches, and the annual contribution of lime in solution in the forms of carbonates and sulphates at 70 tons per square mile.

With these elements, and giving due weight to certain physical considerations that have been urged in limitation of the earth's age, the author proceeds to his calculations, arriving at this result, that the elimination of the calcareous matter contained in the sedimentary crust of the earth must have occupied at least 600 millions of years. The actual time occupied in the formation of the groups of strata as divided into relative ages by Professor Ramsay, is inferred as follows:—

	Millions of years.
Laurentian, Cambrian, and Silurian	200
Old Red, Carboniferous, Permian, and New Red	200
Jurassic, Wealden, Cretaceous, Eocene, Miocene, Pliocene, and Post-pliocene	200
	600

The concluding part of the paper consists of answers to objections. The author contends that the facts adduced prove geological time to be enormously in excess of the limits urged by some physicists, and ample to allow on the hypothesis of evolution for all the changes which have taken place in the organic world.

VI. "Preliminary Note on the Substances which produce the Chromospheric Lines." By J. NORMAN LOCKYER, F.R.S.
Received December 24, 1878.

Hitherto, when observations have been made of the lines visible in the sun's chromosphere, by means of the method introduced by Janssen and myself in 1868, the idea has been that we witness in solar storms the ejection of vapours of metallic elements with which we are familiar from the photosphere.

A preliminary discussion of the vast store of observations recorded by the Italian astronomers (chief among them Professor Tacchini), Professor Young, and myself, has shown me that this view is in all probability unsound. The lines observed are in almost all cases what I have elsewhere termed and described as *basic lines*; of these I only need for the present refer to the following:—

- b_3 ascribed by Ångström and Kirchhoff to iron and nickel.
- b_4 „ Ångström to magnesium and iron.
- 5268 by Ångström to cobalt and iron.
- 5269 „ „ calcium and iron.
- 5235 „ „ cobalt and iron.
- 5017 „ „ nickel.
- 4215 „ „ calcium, but to strontium by myself.
- 5416 an unnamed line.

Hence, following out the reasoning employed in my previous paper, the bright lines in the solar chromosphere are chiefly lines due to the not yet isolated bases of the so-called elements, and the solar phenomena in their totality are in all probability due to dissociation at the photospheric level, and association at higher levels. In